

**WE CLAIM:**

1. An intersubband (ISB) nonlinear optical device comprising:  
a cavity resonator including a ridge waveguide,  
said waveguide including a nonlinear mixing region and a core region, said mixing  
5 region and said core region being monolithically integrated within said waveguide,  
said core region including an active region comprising a multiplicity of repeat units,  
each repeat unit including a unipolar radiative transition (RT) region and a relaxation/injection  
(I/R) region adjacent thereto,  
said RT regions generating lasing light at at least one first center frequency via  
10 intersubband optical transitions in response to pumping energy applied thereto, and  
said nonlinear mixing region generating parametric light at at least one second center  
frequency, different from said first center frequency, in response to said lasing light,  
characterized in that  
said waveguide is configured so that (i) said lasing light is generated in a first  
15 transverse mode and said parametric light is generated in a second, different transverse mode,  
and (ii) the effective-refractive-index-versus-ridge-width characteristics of said first and  
second modes intersect one another at a phase matching width, and  
said ridge width is essentially equal to said phase matching width.
- 20 2. The device of claim 1, wherein said core region includes at least one higher  
refractive index region adjacent thereto.
3. The device of claim 2, wherein said core region includes said higher  
refractive index regions on opposite sides of said active region, the thicknesses of said higher  
25 refractive index regions enhancing the overlap between the intensity profiles of the transverse  
modes of said lasing light and said parametric light with said nonlinear mixing region.
4. The device of claim 1, wherein said parametric light second frequency is higher  
than said lasing light first frequency, said lasing light is generated in a zeroth-order transverse  
30 mode, and said parametric light is generated in a higher order transverse mode.
5. The device of claim 4, wherein said parametric light is generated in a second-

order transverse mode.

6. The device of claim 5, wherein said parametric light is generated as a second harmonic of said lasing light.

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7. The device of claim 1, wherein said parametric light second frequency is lower than said lasing light first frequency, said parametric light is generated in a zeroth-order transverse mode, and said lasing light is generated in a higher order transverse mode.

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8. The device of claim 7, wherein said core region includes higher refractive index regions on opposite sides of said active region, the thicknesses of said higher refractive index regions enhancing the overlap between the intensity profiles of the transverse modes of said lasing light and said parametric light with said nonlinear mixing region.

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9. The device of claim 1, wherein said waveguide is also configured so that, at ridge widths greater than said phase matching width, the effective refractive index of said mode having a lower frequency is greater than that of said mode having a higher frequency.

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10. The device of claim 1, wherein said core region includes said nonlinear mixing region.

11. The device of claim 10, wherein said active region includes said nonlinear mixing region.

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12. The device of claim 1, wherein said nonlinear mixing region and said active region are configured so that said lasing light and said parametric light are resonant with ISB transitions in said nonlinear mixing region.

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13. The device of claim 1, wherein said nonlinear mixing region and said active region are configured so that said lasing light and said parametric light are nonresonant with ISB transitions in said nonlinear mixing region.

14. The device of claim 1, wherein said active regions are configured to generate lasing light at at least two center frequencies, and said nonlinear mixing region is configured to respond to said at least two lasing frequencies to generate said parametric light.

5 15. The device of claim 1, wherein said active regions are configured to generate lasing light at a single center frequency, and said nonlinear mixing region is configured to respond to said single lasing frequency to generate said parametric light.

10 16. A monolithically integrated, quantum cascade (QC) nonlinear optical device comprising:

a cavity resonator including a ridge waveguide,  
said waveguide including a nonlinear mixing region and a core region,  
said core region including an active region and higher refractive index  
regions on opposite sides of said active region,

15 said active region including a multiplicity of repeat units disposed within said waveguide, each repeat unit including a unipolar radiative transition (RT) region and a relaxation/injection (I/R) region adjacent thereto,

said nonlinear mixing region being located within said active region,  
said RT regions generating lasing light at at least one first center frequency via

20 intersubband optical transitions in response to pumping current applied thereto, and

said nonlinear mixing region generating parametric light at at least one second center frequency, different from said first center frequency, in response to said lasing light, said parametric light and said lasing light being resonant with intersubband transitions in said RT regions, characterized in that

25 said waveguide is configured so that (i) said lasing light is generated in a first transverse mode and said parametric light is generated in a second, different transverse mode, (ii) the effective-refractive-index-versus-ridge-width characteristics of said first and second modes intersect one another at a phase matching width, and (iii) at ridge widths greater than said phase matching width, the effective refractive index of said mode having a lower

30 frequency is greater than that of said mode having a higher frequency, and

said ridge width is essentially equal to said phase matching width.